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Towards the global monitoring of biodiversity change

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Governments have set the ambitious target of reducing biodiversity loss by the year 2010. The scientific community now faces the challenge of assessing the progress made towards this target and beyond. Here, we review current monitoring efforts and propose a global biodiversity monitoring network to complement and enhance these efforts. The network would develop a global sampling programme for indicator taxa (we suggest birds and vascular plants) and would integrate regional sampling programmes for taxa that are locally relevant to the monitoring of biodiversity change. The network would also promote the development of comparable maps of global land cover at regular time intervals. The extent and condition of specific habitat types, such as wetlands and coral reefs, would be monitored based on regional programmes. The data would then be integrated with other environmental and socioeconomic indicators to design responses to reduce biodiversity loss.

The need for biodiversity monitoring

The Convention on Biological Diversity (CBD; http://www.biodiv.org) aims 'to achieve by 2010 a significant reduction of the current rate of biodiversity loss at the global, regional and national level as a contribution to poverty alleviation and to the benefit of all life on Earth' [1]. The European Union has set an even more stringent target: to halt biodiversity decline by 2010 (Göteborg European Council, 2001†). Examination of current trends [2], as well as the exploration of plausible future scenarios [3], suggests that the CBD 2010 target is unlikely to be achieved unless an unprecedented effort is made, both at the policy and institutional levels, to improve current conservation efforts and to develop new strategies. This would include the implementation of measures targeted at biodiversity conservation inside and outside protected areas [4–6] and at limiting the causes of biodiversity loss in all economic sectors, from energy production to agriculture [7].

To determine how current conservation efforts can be improved and to guide new strategies, it is crucial that our progress towards the CBD 2010 target and beyond is monitored. How this should be done is now the subject of much debate. Most of the discussion has been directed at what indicators should be used based on existing data [8–10]. Recently, Balmford and colleagues [11] suggested that monitoring should be focused on trends in the abundance and distribution of populations and habitat extent, and reviewed the data available for these measures. Here, we go one step further by proposing a global monitoring network of biodiversity to gather new data for these measures and to integrate current monitoring initiatives.

A global monitoring network for biodiversity

Biodiversity is defined in the CBD as the 'the variability among living organisms from all sources including, inter alia, terrestrial, marine and other aquatic ecosystems and the ecological complexes of which they are part; this includes diversity within species, between species and of ecosystems' [12]. This is a broad concept with many dimensions. For the purposes of biodiversity monitoring, we focus on two scales: regional and global, and two levels: species and ecosystems. These levels of biodiversity have particular implications at each scale for the delivery of ecosystem services (Box 1).

Current biodiversity monitoring programmes suffer from three main constraints [2,9,13]: incomplete taxonomic and spatial coverage; lack of compatibility between data sets owing to different collection methodologies; and insufficient integration at different scales. We propose a pragmatic approach to the global monitoring of biodiversity to tackle these issues, with global- and regional-scale programmes at the species and ecosystem levels (Figure 1). Whereas the ecosystem-level component will provide information about land cover, the species component will provide information about aspects of ecosystem condition. The global-scale programmes would follow a top-down approach, with an emphasis on central coordination, whereas the regional-scale programmes would follow a bottom-up approach, with an emphasis on regional needs and capabilities. The scientific community would have a major role in designing and implementing the network, including: a monitoring programme for the regular global sampling of indicator taxa of terrestrial biodiversity; a global network of regional programmes monitoring indicator populations for terrestrial, freshwater and

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† See: http://ue.eu.int/ueDocs/cms_Data/docs/pressData/en/ec/00200-r1.en1.pdf

 0169-5347/$ - see front matter doi:10.1016/j.tree.2005.10.015

Box 1. Ecosystem services

Ecosystem services are the benefits that people obtain from ecosystems, and can be divided into four groups (Figure I): provisioning services, regulating services, cultural services and supporting services. We generally only recognize services that have a market value, such as provisioning services and some cultural services, but we benefit from other cultural services (including the existence values that people place on conserving wild biodiversity) and regulating services, and, indirectly, from supporting services.

Each type of ecosystem service depends on particular components of biodiversity. The population abundance of species at the local level is important for ensuring the delivery of regional ecosystem services, such as forest foods and pest control, and is also important for recreational services, such as bird watching. Some studies suggest that supporting and regulating services depend not only on population abundances, but also on species richness and composition (e.g. primary productivity) [38–41]. Global species diversity delivers an important cultural service because of existence values; for example, people place a high value in conserving charismatic species, such as the California condor *Gymnogyps californianus* and the Iberian lynx *Lynx pardinus*. The extent of particular habitats, such as wetlands, forests or coral reefs, is also important for ecosystem services at the local and global scales. For instance, run-off regulation and firewood production are delivered at a regional scale, whereas carbon sequestration is delivered at the global scale. Finally, the diversity of ecosystems is important both in terms of scenic D.W. D.W. beauty (a regional cultural service) and existence values (a global cultural service).

The recently concluded Millennium Ecosystem Assessment [42] provides the most comprehensive assessment to date of the status and trends of ecosystem services. The Assessment finds that most ecosystem services are in decline. However, whereas some ecosystem services (e.g. food and some other provisioning services) are routinely monitored, most ecosystem services are monitored only sporadically. Enhanced efforts to monitor the state of ecosystem services themselves would be needed to complement the global biodiversity-monitoring programme proposed here.

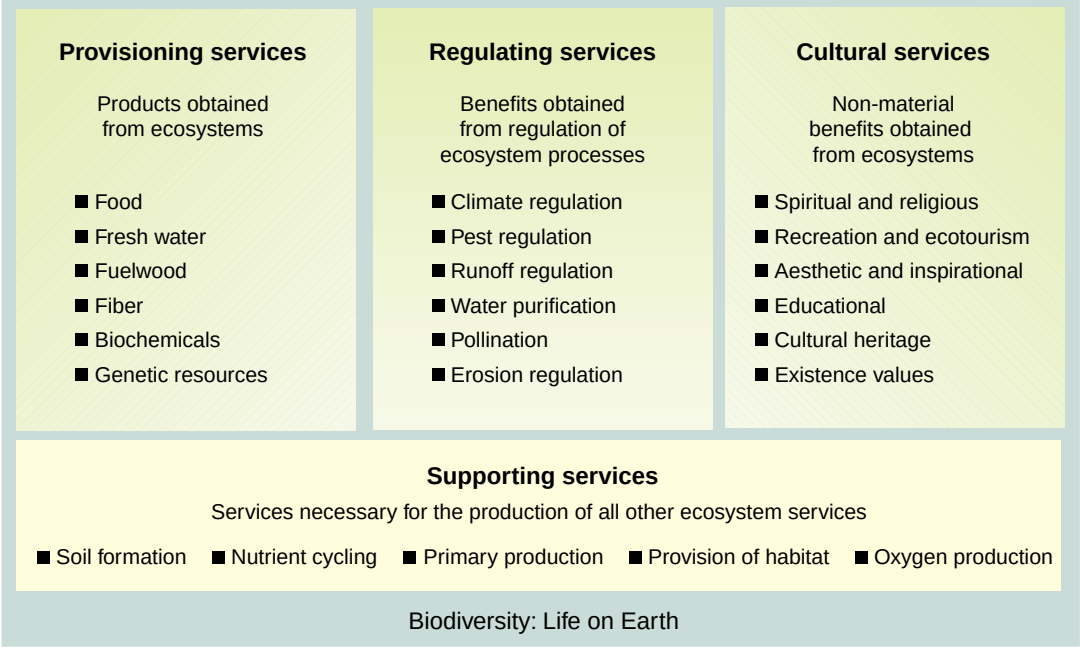

Figure I. A classification of ecosystem services. Modified with permission from [40].

marine biodiversity; the production of regular and comparable global land-cover maps based on remote sensing; a global network of regional programmes monitoring habitats that are best monitored, or have particular relevance, at the regional level.

Species level monitoring

The taxonomic coverage of current species-monitoring programmes is incomplete [14]. Although this is a limitation, it was not until recently that we had global distribution maps of species of one of the most well known groups, terrestrial vertebrates. These maps are now being produced in the context of Global Assessments for amphibians, reptiles, birds and mammals [15,16], conducted by IUCN (http://www.iucn.org), Conservation International (http://www.conservation.org), BirdLife International (http://www.birdlife.net), and other institutions. By contrast, there are few data on global plant distribution. This is a major deficiency given the ecological importance of plants and perhaps also a surprising one, because plants, as a group, are relatively well described [17].

A single snapshot of a species distribution is often insufficient to assess its vulnerability fully. Therefore, the Global Assessments are also compiling information about population trends based on information from experts and available data sets. Similarly, the Living Planet Index (LPI, [18,19]) developed by WWF International (http://www.panda.org) and UNEP-WCMC (http://www.unep-wcmc.org) to measure biodiversity change in the world, compiles 3000 population trends for <1100 vertebrate species, including freshwater, terrestrial and marine species. However, the selection of populations was constrained by data availability. For instance, most species are from temperate regions and, even within each species, the data are not spatially representative of